U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-256 602

Witmer Lake, LaGrange County, Indiana

Pacific Northwest Environmental Res. Lab.

Prepared For
National Environmental Res. Ctr.

March 1976

TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Witmer Lake, LaGrange County, Indiana		5. REPORT DATE Prepared March, 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 349
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114		

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		36 pp.
	20. SECURITY CLASS *(This page)*	22. PRICE
		4.00

EPA Form 2220-1 (9-73)

PRICES SUBJECT TO CHANGE

243048

PB 256 602

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

G.P.O. 699-440

REPORT
ON
WITMER LAKE
LAGRANGE COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 349

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
MARCH, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in respo : to an Administration commitment to investigate the nationwide .reat of accele ated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

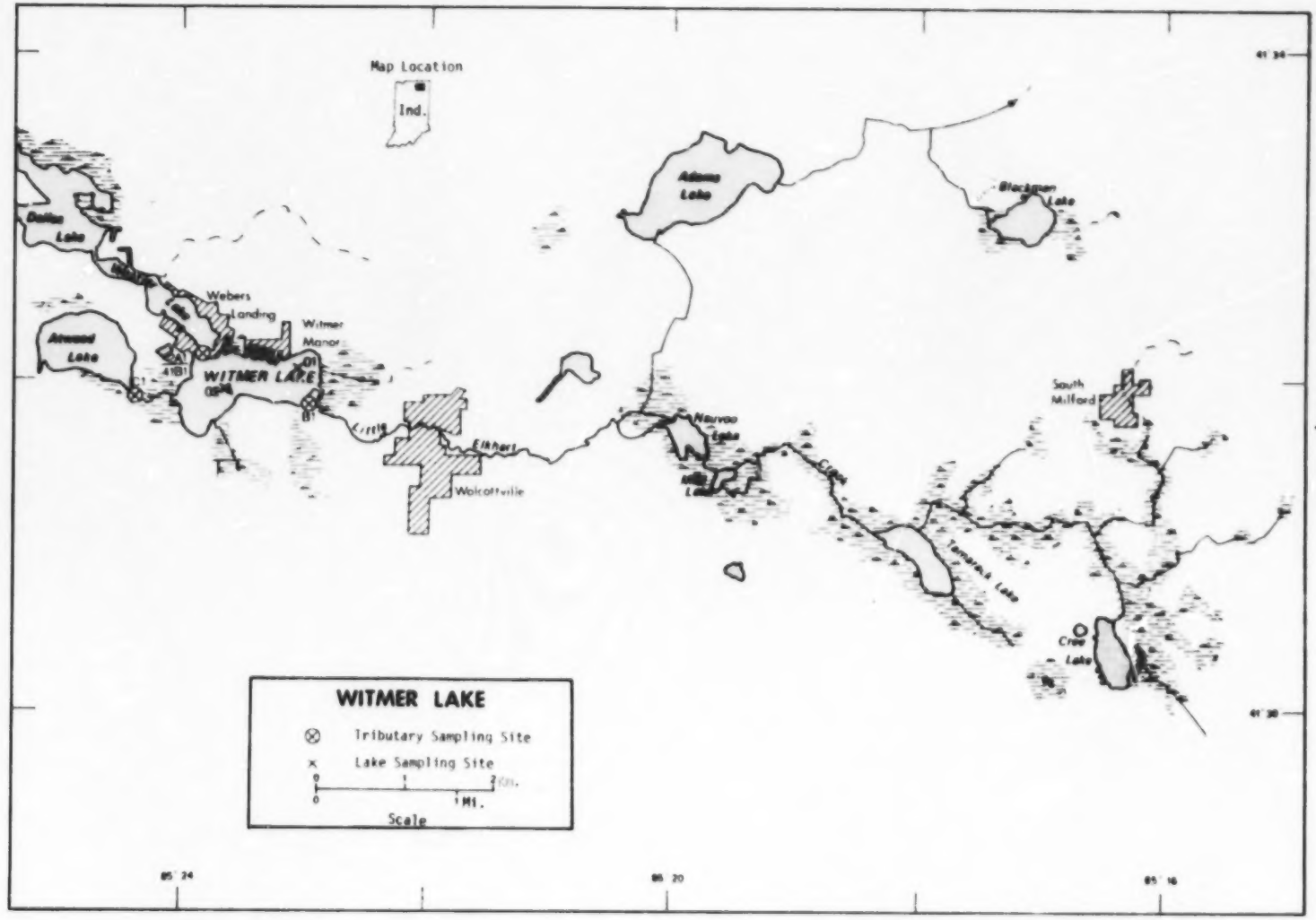
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


Map Location
Ind.
41°34'
41°30'
85°24'
85°20'
85°16'
Webers Landing
Witmer Manor
WITMER LAKE
Atwood Lake
Adams Lake
Blackman Lake
Nauvoo Lake
Crane Lake
Tamarack Lake
South Milford
Wolcottville
WITMER LAKE
Tributary Sampling Site
Lake Sampling Site
0 1 2 Km.
0 1 Mi.
Scale

WITMER LAKE

STORET NO. 1842

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Witmer Lake is eutrophic. Of the 27 Indiana lakes sampled in 1973, Witmer Lake ranked fifteenth in overall trophic quality using a combination of six parameters*. Twelve lakes had less and two had the same median total phosphorus, 12 had less and one had the same median dissolved phosphorus, 13 had less median inorganic nitrogen, 15 had less mean chlorophyll a, and 13 had greater mean Secchi disc transparency.

Survey limnologists noted algal blooms at both stations in August and October, and dissolved oxygen was depleted in the hypolimnion at both stations at those times.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Witmer Lake was phosphorus limited at the time the assay sample was collected (05/03/73). However, the lake data indicate nitrogen limitation in August and October.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Witmer Lake received a total phosphorus loading nearly 2½ times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic

* See Appendix A.

loading (see page 11). The only known point source, Wolcottville, contributed just over 8% of the total phosphorus load.

While even complete removal of phosphorus at the Wolcottville wastewater treatment plant would still leave a loading about twice the eutrophic loading, it is possible that a high degree of phosphorus removal at this source would result in persistent phosphorus limitation (see page 7) and a reduction in the incidence and severity of nuisance algal blooms. Also, phosphorus control might benefit downstream Westler Lake (see map, page v). Note that 67% of the phosphorus load to Witmer Lake was not retained and moved on into Westler Lake. Dallas Lake, just downstream from Westler Lake, probably would benefit also.

2. Non-point sources--During the sampling year, the non-point phosphorus contributions of the Witmer Lake tributaries and immediate drainage accounted for just over 90% of the total phosphorus load to the lake. However, the phosphorus exports of the gaged tributaries do not appear to be excessive (see page 10).

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.83 kilometers^2.
2. Mean depth: 10.4 meters.
3. Maximum depth: 16.5 meters.
4. Volume: 8.632×10^6 m^3.
5. Mean hydraulic retention time: 115 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Little Elkhart Creek	82.1	0.78
Unnamed Stream C-1	3.4	0.03
Minor tributaries & immediate drainage -	7.2	0.06
Totals	92.7	0.87

2. Outlet -

Westler Lake inlet	93.5**	0.87**

C. Precipitation***:

1. Year of sampling: 111.6 centimeters.
2. Mean annual: 91.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Witmer Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 11.6 meters at station 1 and 14.9 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WITMER LAKE
STORET CODE 1842

PARAMETER	1ST SAMPLING (5/ 3/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 3/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/12/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	9.1 - 13.1	11.8	12.7	9.9 - 24.3	16.4	13.4	8.6 - 18.9	14.4	15.9
DISS OXY (MG/L)	7.6 - 9.7	8.9	9.4	0.0 - 8.6	3.7	2.0	0.0 - 9.6	3.8	0.0
CNDCTVY (MCROMO)	500. - 530.	516.	520.	362. - 460.	407.	398.	371. - 397.	387.	396.
PH (STAND UNITS)	8.0 - 8.3	8.2	8.2	7.4 - 8.5	7.9	7.6	7.3 - 8.5	7.9	7.6
TOT ALK (MG/L)	206. - 220.	215.	218.	190. - 280.	216.	208.	179. - 236.	205.	195.
TOT P (MG/L)	0.021 - 0.035	0.029	0.027	0.029 - 0.320	0.184	0.042	0.033 - 0.390	0.128	0.040
ORTHO P (MG/L)	0.004 - 0.014	0.009	0.007	0.005 - 0.278	0.075	0.022	0.010 - 0.410	0.102	0.016
NO2+NO3 (MG/L)	0.810 - 0.990	0.874	0.840	0.080 - 1.080	0.385	0.170	0.020 - 0.050	0.030	0.030
AMMONIA (MG/L)	0.060 - 0.190	0.086	0.070	0.060 - 1.400	0.386	0.090	0.040 - 4.000	0.964	0.100
KJEL N (MG/L)	0.700 - 1.100	0.954	1.000	1.100 - 5.000	1.800	1.400	0.980 - 4.100	1.827	1.290
INORG N (MG/L)	0.870 - 1.120	0.960	0.910	0.150 - 1.620	0.691	0.370	0.060 - 4.030	0.994	0.120
TOTAL N (MG/L)	1.560 - 2.030	1.828	1.830	1.380 - 5.120	2.185	1.680	0.920 - 4.130	1.857	1.240
CHLRPYL A (UG/L)	10.5 - 11.7	11.1	11.1	11.2 - 11.2	11.2	11.2	13.1 - 13.4	13.4	13.4
SECCHI (METERS)	1.5 - 1.7	1.6	1.6	1.4 - 1.5	1.4	1.4	1.5 - 1.5	1.5	1.5

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Algal Units per ml
08/03/73	1. Aphanizomenon sp.	522
	2. Oscillatoria sp.	197
	3. Tabellaria sp.	169
	4. Gomphosphaeria sp.	169
	5. Oocystis sp.	85
	Other genera	240
	Total	1,382
10/12/73	1. Aphanizomenon sp.	882
	2. Oscillatoria sp.	463
	3. Flagellates	433
	4. Lyngbya sp.	374
	5. Cryptomonas sp.	120
	Other genera	313
	Total	2,585

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/03/73	1	10.5
	2	11.7
08/03/73	1	11.2
	2	11.2
10/12/73	1	13.8
	2	13.1

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.015	0.554	5.2
0.050 P	0.065	0.554	11.5
0.050 P + 1.0 N	0.065	1.554	17.9
1.0 N	0.015	1.554	5.0

* The May phytoplankton sample was lost in shipment.

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Witmer Lake was high at the time the assay sample was collected (05/03/73). The results also indicate that the lake was phosphorus limited. Note the lack of increase in the yield when only nitrogen was added; but, when orthophosphorus alone was added, the yield was doubled.

The lake data also indicate phosphorus limitation in May (the mean inorganic nitrogen/orthophosphorus ratio was 120/1) but nitrogen limitation in August and October (the mean N/P ratios were 9/1 and 10/1, respectively).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station C-1 and multiplying by the ZZ area in km^2.

The operator of the Wolcottville wastewater treatment plant provided monthly effluent samples and corresponding flow data.

Note that the estimated septic tank phosphorus loading was reduced by 60% to adjust for the Indiana phosphate detergent ban instituted in January, 1972.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Wolcottville	900	tr. filter + pond	151.7	Little Elkhart Creek

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Little Elkhart Creek	1,985	87.4
Unnamed Stream C-1	20	0.9
b. Minor tributaries & immediate drainage (non-point load) -	45	2.0
c. Known municipal STP's -		
Wolcottville	190	8.3
d. Septic tanks** -	15	0.7
e. Known industrial - None	-	-
f. Direct precipitation*** -	15	0.7
Total	2,270	100.0

2. Outputs -

Lake outlet - Westler Lake inlet 1,530

3. Net annual P accumulation - 740 kg.

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* Lower, 1973.
** Estimate based on 110 lakeshore dwellings; see Working Paper No. 175.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Little Elkhart Creek	59,245	89.6
Unnamed Stream C-1	1,295	2.0
b. Minor tributaries & immediate drainage (non-point load) -	2,745	4.2
c. Known municipal STP's -		
Wolcottville	760	1.1
d. Septic tanks* -	1,170	1.8
e. Known industrial - None	-	-
f. Direct precipitation** -	895	1.4
Total	66,110	100.0

2. Outputs -

Lake outlet - Westler Lake inlet 53,730

3. Net annual N accumulation - 12,380 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Little Elkhart Creek	24	722
Unnamed Stream C-1	6	381

* Estimate based on 110 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	2.73	0.89	79.7	14.9

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Witmer Lake:	
"Dangerous" (eutrophic loading)	1.12
"Permissible" (oligotrophic loading)	0.56

V. LITERATURE REVIEWED

Lower, Tom, 1973. Treatment plant questionnaire (Wolcottville STP). Wolcottville.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATAWACT LAKE	0.059	1.660	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.623	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLEY LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.967	15.000	0.014
1846	OLIN LAKE	0.012	1.440	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.089	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.850	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.137	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CHOURED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.018	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.180	15.000	0.150
1855	PIGEON LAKE	0.058	1.945	442.667	11.980	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.035
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SUB-MEAN SEC	MEAN CHLORA	IS-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MOWSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1848	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	95 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1838	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITHER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1842 MICHIGAN LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 93.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1842A1	93.5	1.15	1.35	1.89	1.78	1.16	0.87	0.53	0.28	0.18	0.28	0.46	0.84	0.88
1842B1	82.1	1.01	1.18	1.67	1.56	1.01	0.77	0.47	0.17	0.16	0.17	0.40	0.85	0.78
1842C1	3.4	0.037	0.048	0.071	0.065	0.040	0.031	0.018	0.005	0.005	0.005	0.016	0.034	0.031
1842Z2	6.5	0.071	0.091	0.136	0.125	0.079	0.062	0.037	0.010	0.010	0.010	0.031	0.062	0.060

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 93.5
SUM OF SUB-DRAINAGE AREAS = 91.9
TOTAL FLOW IN = 10.52
TOTAL FLOW OUT = 10.61

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1842A1	6	73	1.472	9	2.152				
	7	73	0.991	14	1.019				
	8	73	0.736	12	0.708				
	9	73	0.510	8	0.538				
	10	73	0.453	6	0.453				
	11	73	0.453	9	0.396				
	12	73	0.878	8	0.651				
	1	74	1.472	9	0.878				
	2	74	1.812	9	2.039	23	2.152		
	3	74	2.209	9	2.832	23	1.982		
	4	74	1.586	13	1.812				
	5	74	1.444	11	1.218				
1842B1	6	73	1.274	9	1.869				
	7	73	0.858	14	0.878				
	8	73	0.651	12	0.595				
	9	73	0.425	8	0.453				
	10	73	0.396	6	0.396				
	11	73	0.368	9	0.368				
	12	73	0.765	8	0.566				
	1	74	1.274	9	0.765				
	2	74	1.586	9	1.756	23	1.812		
	3	74	1.897	9	2.435	23	1.756		
	4	74	1.331	13	1.869				
	5	74	1.246	11	1.048				

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1842 WITMER LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1842C1	6	73	0.054	9	0.079				
	7	73	0.034	14	0.037				
	8	73	0.025	12	0.025				
	9	73	0.017	8	0.020				
	10	73	0.014	6	0.017				
	11	73	0.017	9	0.014				
	12	73	0.031	8	0.023				
	1	74	0.051	9	0.048				
	2	74	0.062	9	0.076	23	0.079		
	3	74	0.076	9	0.105	23	0.071		
	4	74	0.054	13	0.068				
	5	74	0.048	11	0.045				
1842Z2	6	73	0.105	9	0.153				
	7	73	0.065	14	0.071				
	8	73	0.048	12	0.048				
	9	73	0.034	8	0.037				
	10	73	0.028	6	0.034				
	11	73	0.034	9	0.028				
	12	73	0.059	8	0.042				
	1	74	0.099	9	0.093				
	2	74	0.119	9	0.153	23	0.153		
	3	74	0.147	9	0.201	23	0.136		
	4	74	0.102	13	0.130				
	5	74	0.093	11	0.088				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

184201
41 32 03.0 085 23 05.0 3
WITMER LAKE
18087 INDIANA

11EPALES 2111202
0042 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	14 35	0000	13.1		66	520	8.20	218	0.070	0.900	0.820	0.006
	14 35	0006	13.1	7.6		520	8.30	216	0.060	1.000	0.810	0.008
	14 35	0015	13.0	9.4		520	8.30	214	0.060	1.100	0.810	0.007
	14 35	0022	13.0	9.6		520	8.30	206	0.060	1.000	0.820	0.007
	14 35	0030	12.6	9.5		510	8.20	206	0.070	1.000	0.830	0.009
	14 35	0038	9.3	7.7		530	8.00	208	0.190	1.100	0.930	0.014
73/08/03	11 00	0000	24.3	8.6	54	457	8.50	191	0.090	1.600	0.080	0.005
	11 00	0005	24.2	8.3		450	8.50	190	0.060	1.400	0.090	0.006
	11 00	0010	23.9			460						
	11 00	0015	22.5	4.1		460	7.60	196	0.090	1.200	0.220	0.022
	11 00	0020	14.1	0.3		400	7.50	218	0.110	1.100	0.880	0.038
	11 00	0025	12.8			382						
	11 00	0030	11.7			374						
	11 00	0035	10.7			370						
	11 00	0037	10.6	0.0		372	7.40	265	1.390	2.400	0.110	0.250
73/10/12	10 10	0000	18.9	9.6	60	395	8.50	181	0.060	1.200	0.040	0.015
	10 10	0010	18.8	9.0		396	8.50	181	0.060	1.200	0.020	0.010
	10 10	0015	18.8	7.0		397	8.20	184	0.060	1.100	0.020	0.010
	10 10	0025	12.2	0.0		387	7.60	222	0.430	1.400	0.020	0.014
	10 10	0032	9.9	0.0		373	7.40	232	1.450	2.500	0.040	0.148
	10 10	0038	9.2	0.0		378	7.30	236	2.940	3.400	0.050	0.322

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	14 35	0000	0.023	10.5
	14 35	0006	0.035	
	14 35	0015	0.035	
	14 35	0022	0.034	
	14 35	0030	0.026	
	14 35	0038	0.033	
73/08/03	11 00	0000	0.032	11.2
	11 00	0005	0.033	
	11 00	0015	0.044	
	11 00	0020	0.055	
	11 00	0037	0.313	
73/10/12	10 10	0000	0.036	13.8
	10 10	0010	0.033	
	10 10	0015	0.038	
	10 10	0025	0.044	
	10 10	0032	0.214	
	10 10	0038	0.390	

STORET RETRIEVAL DATE 76/03/30

184202
41 32 01.0 085 23 41.0 3
WITMER LAKE
18047 INDIANA

11EPALES 2111202
0052 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	15 05	0000	12.7		60	500	8.20	220	0.070	1.100	0.040	0.005
	15 05	0006	12.7	9.7		500	8.30	220	0.060	0.900	0.040	0.005
	15 05	0015	12.7	9.7		510	8.30	220	0.060	0.900	0.050	0.004
	15 05	0022	12.3	9.4		510	8.20	216	0.060	0.700	0.060	0.005
	15 05	0031	9.9	8.5		525	8.10	218	0.110	0.900	0.970	0.008
	15 05	0040	9.3	8.4		520	8.00	218	0.120	1.000	0.990	0.010
	15 05	0048	9.1	8.2		520	8.00	218	0.130	0.900	0.990	0.011
73/08/03	11 50	0000	24.1	8.4	58	454	8.50	192	0.080	1.400	0.080	0.011
	11 50	0005	24.0	8.4		451	8.50	192	0.090	1.300	0.080	0.009
	11 50	0010	23.9			453						
	11 50	0015	21.8	2.8		453	7.80	208	0.110	1.300	0.260	0.012
	11 50	0020	14.9	0.6		398	7.50	226	0.090	1.100	1.000	0.030
	11 50	0025	12.4			388						
	11 50	0030	11.6			372						
	11 50	0035	10.9	0.0		366	7.40	222	0.040	2.000	0.430	0.167
	11 50	0040	10.4			362						
	11 50	0045	10.0			363						
	11 50	0048	9.9	0.0		365	7.40	208	1.500	5.000	0.120	0.278
73/10/12	10 50	0000	10.9	9.0	60	396	8.40	179	0.060	1.100	0.030	0.024
	10 50	0015	10.5	7.6		394	8.20	179	0.040	1.000	0.020	0.016
	10 50	0020	15.9	8.8		395	7.60	195	0.100	0.900	0.020	0.016
	10 50	0030	9.9	8.8		372	7.40	236	1.400	2.200	0.040	0.141
	10 50	0049	8.6	0.0		371	7.30	234	4.000	4.100	0.030	0.410

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	15 05	0000	0.029	11.7
	15 05	0006	0.025	
	15 05	0015	0.021	
	15 05	0022	0.021	
	15 05	0031	0.023	
	15 05	0040	0.027	
	15 05	0048	0.029	
73/08/03	11 50	0000	0.031	11.2
	11 50	0005	0.029	
	11 50	0015	0.030	
	11 50	0020	0.042	
	11 50	0035	0.289	
	11 50	0048	0.329	
73/10/12	10 50	0000	0.048	13.1
	10 50	0015	0.035	
	10 50	0020	0.035	
	10 50	0030	0.144	
	10 50	0049	0.376	

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/03/30

1842A1 and 1841B1
41 32 12.0 085 23 50.0 4
WESTLER-WITMER LAKE CONNECTION
18 7.5 OLIVER LAKE
O/WHITMER LAKE
700 S RD BRDG SW OF WEBERS LANDING
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 40		0.330	1.900	0.056	0.007	0.040
73/07/14	12 10		0.017	1.260	0.024	0.006	0.015
73/08/12	12 10		0.010K	1.050	0.016	0.011	0.020
73/09/08	09 35		0.010K	0.940	0.022	0.005K	0.020
73/10/06			0.010K	2.100	0.032	0.005K	0.030
73/11/09	12 15		0.028	1.250	0.310	0.048	0.090
73/12/08	09 00		0.088	1.600	0.288	0.016	0.080
74/01/09			0.630	1.200	0.232	0.016	0.075
74/02/09	11 00		1.760	1.100	0.110	0.020	0.075
74/02/23	10 10		1.180	0.900	0.090	0.010	0.045
74/03/09	13 00		1.280	1.200	0.185	0.040	0.100
74/03/23	11 20		1.340	1.100	0.085	0.025	0.055
74/04/13	09 30		1.200	1.550	0.027	0.012	0.012
74/05/11	15 00		0.830	0.950	0.155	0.035	0.110

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

184281
41 32 55.0 085 23 00.0 4
LITTLE ELKHART CREEK
18 7.5 OLIVER LAKE
I/WHITMER LAKE
SEC RD BRDG NEAR MOUTH OF CREEK
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	14 10		0.280	2.310	0.075	0.021	0.075
73/07/14	13 00		0.189	2.000	0.056	0.027	0.070
73/08/12	12 45		0.198	1.150	0.046	0.044	0.075
73/09/08	10 00		0.220	0.750	0.040	0.036	0.085
73/10/06			0.320	1.050	0.072	0.068	0.110
73/11/09	13 10		0.640	1.180	0.168	0.076	0.102
73/12/08	09 00		0.490	1.400	0.132	0.040	0.105
74/01/09			1.600	1.100	0.128	0.024	0.100
74/02/09	11 30		2.000	1.100	0.080	0.005	0.045
74/02/23	18 45		2.300	1.300	0.100	0.050	0.100
74/03/09	13 30		1.680	1.700	0.160	0.060	0.165
74/03/23	11 30		1.300	1.400	0.055	0.020	0.055
74/04/13	10 00		0.980	1.900	0.065	0.020	0.025
74/05/11	15 20		0.850	1.900	0.162	0.027	0.115

STORET RETRIEVAL DATE 76/03/30

1842C1
41 32 00.0 085 24 30.0 4
UNNAMED STREAM
18 7.5 OLIVER LAKE
I/WHITMER LAKE
END SEC RD SW OF CAMP OKALONA
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13 55		0.018	0.780	0.021	0.005K	0.015
73/07/14	12 45		0.021	2.300	0.061	0.005K	0.010
73/08/12	12 30		0.010K	0.650	0.015	0.012	0.025
73/09/08	09 45		0.010K	0.540	0.016	0.005K	0.012
73/10/06			0.010K	0.800	0.032	0.005K	0.022
73/11/09	12 20		0.028	0.750	0.040	0.008	0.030
73/12/08	09 00		0.064	1.200	0.044	0.005K	0.010
74/02/04	11 15		0.600	1.300	0.175	0.005K	0.045
74/02/23	10 30		0.420	1.200	0.125	0.005	0.010
74/03/09	09 30		0.184	0.700	0.050	0.010	0.045
74/03/23	12 00		0.260	1.600	0.037	0.005K	0.020
74/04/13	09 45		0.232	1.100	0.030	0.005	0.020
74/05/11	15 20		0.850	1.000	0.195	0.045	

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1842BA TF1842BA P000900
41 31 42.0 085 22 16.0 4
WALCOTTVILLE
18 7.5 WOLCOTTVILLE
T/WHITMER LAKE 083291
LITTLE ELKHART CR
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/18	11 00		1.040	7.170	0.270	2.390	2.800	0.032	0.035
73/07/17	08 00		1.890	6.600	0.220	2.100	2.900	0.026	0.030
73/08/22	13 30		0.800	7.350	0.815	2.760	3.350	0.021	0.026
73/09/24	13 00		1.200	10.400	0.640	3.500	4.200	0.022	0.020
73/10/21			1.540	14.000		3.600	4.300	0.023	0.022
73/11/28	13 00		0.910	17.800	8.400	2.940	4.400	0.055	0.048
74/01/02	13 00		0.200	20.000	5.200	3.200	4.400	0.047	0.048
74/01/29	13 00		1.400	9.300	0.048	1.480	3.430	0.047	0.046
74/02/26	14 00		0.840	16.000	4.200	2.600	3.500	0.060	0.048
74/03/29	15 00		0.040	15.000	3.900	2.400	3.200	0.048	0.052
74/06/04	09 00		2.000	9.200	0.460	1.400	1.800	0.052	0.056
74/07/15	13 30			3.100			3.200	0.044	0.050